Contribution to the knowledge of the genus *Zygaena* Fabricius, 1775, in Iran (Zygaenidae). Part IX: On two newly discovered *Mesembrynus* taxa from the central and southern Zagros range

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Abstract. Two new taxa of the genus *Zygaena* are described from the Iranian Zagros range: *Zygaena mirzayansi* sp. n. from the central part of the Zagros and *Z. fredi valii* ssp. n. from the mountainous regions in the province Kerman. There are observations on the preimaginal biology of the two taxa. For *Z. mirzayansi* sp. n., the full grown larva is known. It was found on *Eryngium billardieri*. *Zygaena fredi valii* ssp. n. feeds on *Bupleurum exaltatum* (M. Bieb.) or a very close related *Bupleurum*. The larvae of *Z. fredi syntopica, Z. fredi escaleraiana* and *Z. mirzayansii* are figured for the first time. The type-localities of *Z. fredi escaleraiana* and *Z. escalerai* have been located more precisely. The types of *Z. fredi*, *Z. fredi escaleraiana*, *Z. fredi syntopica* and *Z. mirzayansi* are figured.

Zusammenfassung. Aus dem iranischen Zagrosgebirge werden zwei neue Zygaenentaxa beschrieben: *Zygaena mirzayansi* sp. n. aus dem zentralen Zagros und *Z. fredi valii* ssp. n. aus den Gebirgsregionen der Provinz Kerman. Beobachtungen zur Präimginalbiologie beider Taxa sind sehr spärlich. Von *Z. mirzayansi* sp. n. ist die erwachsene Raupe bekannt. Sie wurde auf *Eryngium billardieri* gefunden. *Zygaena fredi valii* ssp. n. lebt an *Bupleurum exaltatum* (M. Bieb.) oder einer sehr verwandten *Bupleurum* Art. Erstmals werden die Larven von *Z. fredi syntopica, Z. fredi escaleraiana* und *Z. mirzayansi* abgebildet. Die Typenlokalität von *Z. fredi escaleraiana* und *Z. escalerai* konnte präzisiert werden. Von *Z. fredi*, *Z. fredi escaleraiana*, *Z. fredi syntopica* und *Z. mirzayansi* werden die Typen abgebildet.

Introduction

The phylogenetic relationships within the *manlia*-group are complicated. Revisions were proposed by Naumann & Racheli (1978), Naumann & Tarmann (1983) and Naumann & Tremewan (1984) but were never published. Although our knowledge of the biology has increased because of recent, intensive fieldwork in Iran, the status of many of the nominal taxa remains unclear. During the last decade, new taxa have been described, including some whose systematic position and status remain unclear (e.g. *Z. ginnereissi* Hofmann, 2000, *Z. rubricollis shahkuhica* Hofmann, 2005, *Z. rubricollis tenhageni* Hofmann & Tremewan, 2003); others have been raised or reinstated to species level (e. g. *Z. nocturna* Ebert, 1974, *Z. aisha* Naumann & Naumann, 1988, *Z. fredi* Reiss, 1938), or transferred from one species to another (e. g. *Z. manlia kermanensis* Tremewan, 1974 to *Z. rubricollis kermanensis*, *Z. manlia araxis* Koch, 1936 to *Z. araxis* and later to *Z. rubricollis araxis*). Investigation of type-material as well as new discoveries of localities where several sympatric species of the *manlia*-group occur are of great importance in determining specific and infraspecific relationships. Some confusion still exists. For example, at Shah-Kuh (Gorgan S.) it seems that, in addition to *Z. cacuminum* Christoph, 1877 and *Z. manlia* Lederer, 1870, there are one or two further species group taxa of the *manlia*-group occurring in this locality. One has been described as *Z. rubricollis shahkuhica* Hofmann, 2005. Another population discovered by T. Keil in the eastern Alborz close to the type-locality of *Z. cacumi-*

num is neither this taxon nor *Z. manlia*. It is at present unnamed and might belong to "*shahkuhica*" although it is reasonably well differentiated, added to which we are still unsure what the taxa "*shahkuhica*" and "*manlia*" really are.
In the vicinity of Semirom (Esfahan), there are biotopes where *Z. fredi* and *Z. rubricollis tenhageni* are syntopic, thus directly confirming their heterospecificity. In the same biotope a third species of the *manlia*-group was found in 2002, and later at other places and provinces (Fars, Chaharmahal-va Bakhtiyari, Esfahan). Another taxon became known to us from the province of Kerman. Several larvae were found on *Bupleurum exaltatum* (M. Bieb.) or a very close related *Bupleurum.* Morphological characters, host-plant association and its distribution provide arguments for conspecifity with *Z. fredi* from the central Zagros range. Here we are describing these new taxa.

Abbreviations

CAHO Collection Axel Hofmann, Breisach-Hochstetten, Germany.
CTKD Collection Thomas Keil, Dresden, Germany.
HMIM Hayk Mirzayans Insect Museum, Tehran, Iran.
NRMS Naturhistoriska Riksmuseet, Stockholm, Sweden.
TLMF Tiroler Landesmuseum Ferdinandeum, Innsbruck, Austria.
ZFMK Zoologisches Forschungsmuseum A. Koenig, Bonn, Germany.

Zygaena fredi Reiss, 1938 — Figs 1, 25, 41

"*Zygaena* (*Peristygia*) *fredi* n. spec." Reiss, H. 1938: 290, fig. d3. Type locality: "Iran, Fars, beim Fort Sine Sefid an der Straße Chiraz-Kazeroun in etwa 2200 m Höhe".

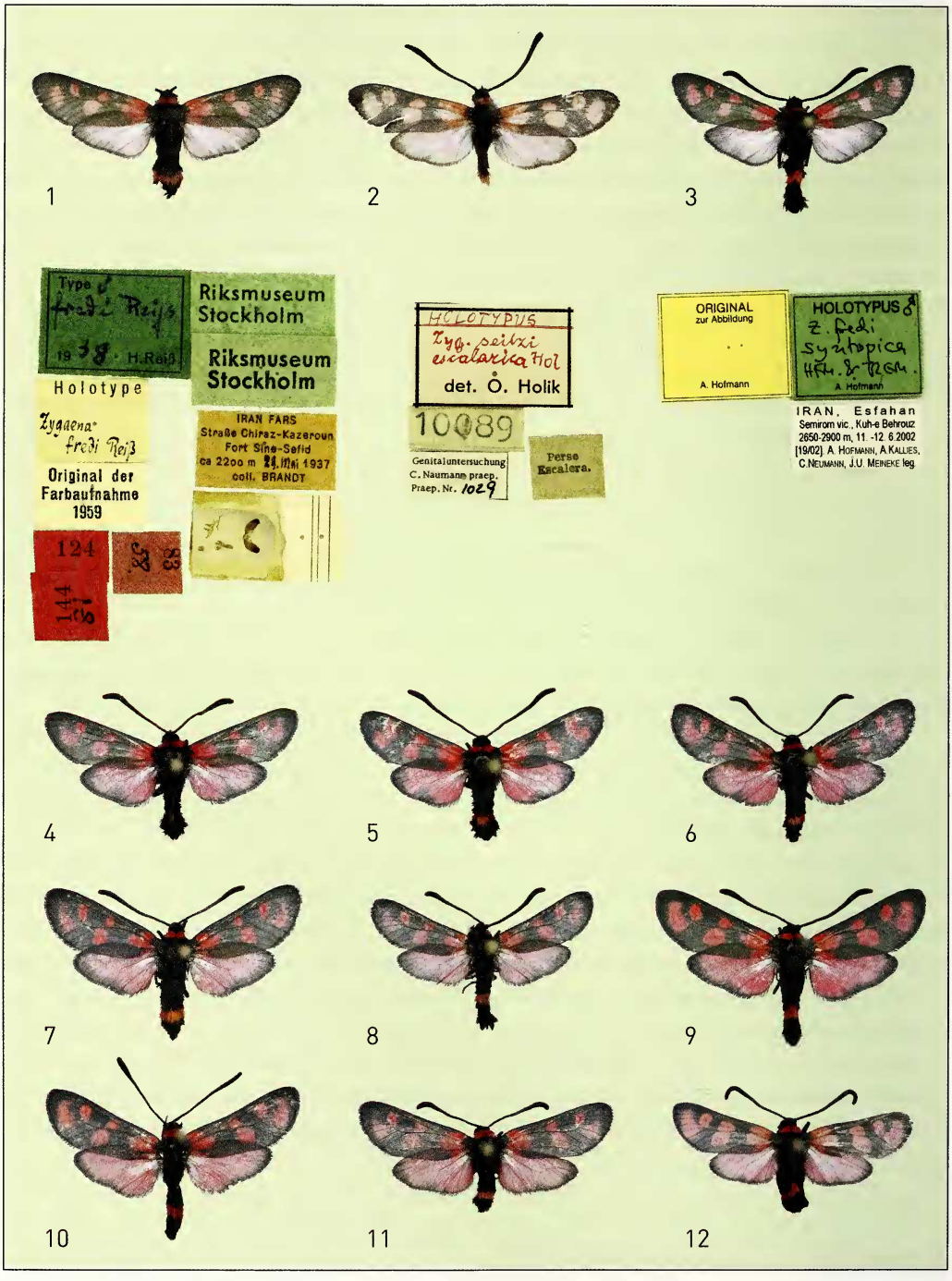
The original description was based on 1♂, 1♀, on loan from Wilhelm Brandt and collected by Fred Brandt on 29 May 1937; one further ♂ was collected but was not available to Reiss, one ♂ is figured (d3) in monochrome and is referred to as "Type", i.e. holotype. While the original figure depicts this specimen with both antennae, both are now lost and the position of the abdomen has changed as genitalia dissection had been made (vide Fig. 1). The holotype is deposited in the NRMS. Taxonomically placed in the *cuvieri*-group, the author compared *Z. fredi* with *Z. cacuminum* and *Z. manlia*.
During fieldwork undertaken in 2002 in the Gol Andaz valley near Deh Bakri (Kerman, Bam W.), G. M. Tarmann and T. Keil found specimens that were not easily referable to any other taxon. The association of these diurnal moths with a yellow-flowered, narrow-leaved *Bupleurum* sp. was readily apparent, as most of the individuals were found close to these plants. The "new taxon" occurred in the biotope together with two further *Mesembrynus* species (*Z. aisha* Naumann & Naumann, 1980, *Z. ginnereissi* Hofmann, 2000), while *Z. chirazica* Reiss, 1938 and *Z. sengana* Holik & Sheljuzhko, 1956, were also observed there. On 10 May, T. Keil found a female depositing eggs on one of these *Bupleurum* plants and a few weeks later (2.vi.2002) A. Kallies found several batches of eggs that were deposited irregularly at the base of the stems inside these plants. The same day the first larvae emerged and accepted only *Bupleurum* as a host-plant.
Based on these observations, specific investigations have been possible during subsequent years to provide new data, especially on the distribution of this *Bupleurum*-

feeding species. Independently, A. Hofmann had already found a few specimens at Shingara (Jiroft N.) the same year. There the moths showed the same association with *Bupleurum* at a site where no *Eryngium* species were present. The same or a very similar *Bupleurum* species was noted in 2005 and 2009 at Kuh-e Garin (Prov. Hamadan), at Kuh-e Bol (Eqlid vic.) and at Semirom (Prov. Esfahan); at the latter site, T. Keil found a full-grown larva of *Z. fredi syntopica* under a stone directly beneath a *Bupleurum* plant on 9.v.2005. Larvae from Semirom were reared in captivity (A. Hofmann, unpubl.) through the diapause stage to L5 on several *Bupleurum* species (*B. falcatum*, *B. rotundifolium*) None of the *Eryngium* species that was offered was accepted.
More than two dozen fully grown larvae (25.6.2009) and batches of eggs (8.7.2005) were observed lower down on the stems of the *Bupleurum* plants at Kuh-e Garin, (Prov. Hamadan, Nahavand SW, Gardaneh-ye Gema Siab, 2,750–2,850 m) (A. Hofmann).
Two fully grown larvae were found on 17.6.2009 at Gardaneh-ye Cheri (Prov. Chaharmahal-va-Bakhtiyari, Zarde-Kuh-reg., Samsami vic., 3,100 m). Like on Kuh-e Garin; they were sitting deep down in the wooden parts of thorny *Astragalus* bushes, amongst which the larval host-plant was present and protected from grazing herbivores (A. Hofmann).
Moreover, a population presumably belonging to *Z. fredi* (or a closely related taxon) was recently discovered in the central Alborz (A. Hofmann, unpubl.). Here, on the south side of the Kendevan pass, a female was noted nectaring at the white flowers of *Cephalaria microcephala* next to a solitary plant of *Bupleurum exaltatum* (M. Bieb.); an intensive search provided a single batch of 35 eggs that had been laid around a stem of the plant (T. Kia-Hofmann, pers. obs.). Two further females were kept in boxes in which both individuals deposited batches of eggs (n = 45), but only on the stems and flowers of *Bupleurum*. After seven days the larvae emerged. As host-plants, only *Bupleurum* species were accepted, the larvae initially showing a preference for the flowers.
There can be no doubt that a widely distributed species, or even a group of species, live on *Bupleurum* spp. in the Irano-Afghan highlands, knowledge that has been overlooked until recently. Very recent fieldwork in 2007 by A. Hofmann in central and eastern Afghanistan confirms this observation. At Kuh-e Paghman (Prov. Kabul), in the vicinity of Panjao (Prov. Bamiyan) and in the Panjshir valley (near Astanah), adults of *Z. rubricollis* Hampson, 1900 were observed in biotopes where only a single species of umbellifer was growing. In captivity, two females from Cheshmeh Gardaneh (Prov. Panjshir, Astanah – Shava) laid eggs on the narrow leaves of an offered *Bupleurum* species, behaviour that is identical to that observed in Iranian *Bupleurum*-feeder species (Hofmann, 2009).

Zygaena fredi escaleraiana Holik, 1958 Figs 2, 26, 42

"*Zygaena* (*Coelestis*) *seitzi escaleraiana* n. ssp." Holik, O. 1958: 68: 17. Type locality: Iran, „Haut-Kharoum, Chindaar Vallée".

The original description was based on 1♂, 1♀ from the "Sammlung René Oberthür, die sich jetzt im Museum Alexander Koenig in Bonn befindet" (Holik, 1958).



The author mentioned that both specimens, labelled "Perse, Escalera", were collected by de la Escalera on the same date and probably at the same site. Holik referred to Poujade (1900) when re-describing *Zygaena escalerai*, specimens of which had the

same labels, and gave more detailed information in the locality: „Haut-Kharoum, Chindaar Vallée". He mentioned that all efforts to find the exact geographical location for this locality had failed.
The ♂ is cited as "Holotypus", the ♀ as "Allotypus"; both were collected "VII. 1899 (?)". The citation on the label is erroneous: "*escalarica*" or "*escalerica*".
Holik compared the specimens with *Z. seitzi* and stated that the only difference is in the coloration of the forewings, which were red instead of yellow. He supposed this red form to be the more ancestral one.
Originally described as a subspecies of *Z. seitzi*, the position of this taxon has remained unclear, as the type specimen had never been figured. We found the original ♂ specimen in coll. C. M. Naumann (now Museum Alexander Koenig, Bonn) where apparently it was on loan for the major revision of the whole *manlia*-group. Although the specimen is not in perfect condition, it is obvious to us that it belongs to the *Bupleurum*-feeding group of species and the nominal taxon *escaleraiana* is here placed as a subspecies of *Z. fredi*. Furthermore, we have succeeded in tracing the exact location of the hitherto doubtful type-locality. Hofmann & Tremewan (1996) inconsistently give: "Iran: Khuzestan, upper reaches of the Karun River ('?Haut-Kharoum, Chindaar vallée')" for *Z. rubricollis escaleraiana* and "Iran: Lorestan, upper reaches of the Karun River ('?Haut-Kharoum, Chindaar vallée')" for *Z. escalerai*. In fact there is a village named "Chendār" that is situated by the Kuhrang river, a primary tributary of the Karun River in the province of Çahārmahāl-va-Bakhtiyāri east of the Zarde-Kuh.
We define here the type-locality for *Z. fredi escaleraiana* and *Z. escalerai* as follows: "Iran, Çahārmahāl-va-Bakhtiyāri, Chelgerd SE., Chendār vic., Ab Kuhrang, [32°18′ 53″N 50°13′12″E]".
Based on phenotypic similarity to the holotype, we provisionally refer the geographically surrounding populations to this subspecies until more material is available:

- Lorestan, Kuh-e Garin, Nahavand SW, 2400–2750 m
- Lorestan, Osturan-Kuh, vic. Dorud, 3200 m
- Esfahan, Khonsar, pass NW, 2800–2900 m
- Esfahan, Khonsar S, Derre Bid, 2600–3000 m
- Esfahan, Fereydun Shahr S, Kamaran valley, 2600–3000 m
- Chaharmahal-va-Bakhtiyari, Zarde-Kuh-region, Samsami vic., 2900–3100 m.

Figs 1–12. *Zygaena fredi.* **1.** *Z. fredi fredi* Reiss, 1938. Holotype, ♂, (NRMS). **2.** *Z. fredi escaleraiana* Holik, 1958. Holotype, ♂, (ZFMK). **3.** *Z. fredi syntopica* Hofmann & Tremewan, 2003. Holotype, ♂, (CAHO). **4–12.** *Z. fredi vallii* n. ssp., **4.** Holotype, ♂, (CAHO). **5.** Paratype, ♂, same data as holotype, (CAHO). **6.** Paratype, ♀, same data as holotype, (CAHO). **7.** Paratype, ♀, "Iran, Kerman, Str. Jiroft-Rayen, 10 km südl. Dalford, 2,400–2,500 m, 22.–23.5.2002, leg. P. Hofmann", (CAHO). **8.** Paratype, ♂, "Iran, Kerman, Jiroft NW, Gardaneh Sarbishan, Shingara vic., 2,900–3,100 m, [07/02], 3.6.2002, A. Hofmann leg.", (CAHO). **9.** Paratype, ♂, „N-Iran, Prov. Kerman, 60 km N Jiroft, 1,950–3,250 m, 16.–25.5.2005, leg. G. Betti", (CAHO), **10.** Paratype, ♀, „Iran, Kerman, Darb-e Behesht, 2,700–2,900 m, 20.–22.5.2001, leg. Ramos & Westphal", (CAHO). **11.** Paratype, ♀, „Südiran, Kerman, Qorhud-Mts., 25 km N Baft, Kefenu-Paß, 2,900 m, 4.6.1998, leg. Keil", (CTKD). **12.** Paratype, ♀, „Südiran, Kerman, Qorhud Mountains, 35 km W Baft, 2,150 m, 17.5.2001, leg. Thomas Keil", (CTKD).

In 2004 and 2005, *Zygaena fredi* was found on the Gardaneh-ye Cheri, a pass in the vicinity of Samsāmi (Zarde-Kuh region), at a higher altitude of around 3,000 m, *ca* 18 km from the type-locality as the crow flies. Here *Z. fredi* is sympatric and partly synchronous with *Z. seitzi*, thus confirming their heterospecificity, although gene flow cannot be completely ruled out as T. Keil found a single specimen of *Z. seitzi* with orange-red forewing spots. However, all other observed specimens (37 males, 14 females of *Z. seitzi*; 6 males, 6 females of *Z. fredi*) are clearly referable to one or the other species. *Zygaena fredi* was observed at the end of its flight period (9–10 July 2005) when the adults of *Z. seitzi* were in fresh condition. The two species are not precisely syntopic, as their biotopes are separated by *ca* 500 m. While *Z. seitzi* flies 100 m higher together with *Z. cambysea* and *Z. bakhtiyari*, in the biotope of *Z. fredi* only *Z. chirazica* was noted. At this site several plants of a narrow-leaved *Bupleurum* sp. were present. *Zygaena seitzi* from Samsāmi was reared *ab ovo* on *Eryngium* spp., as with all other populations of this species. On 17.6.2009, A. Hofmann found fully grown larvae of both species at this site, when the first specimens of *Z. fredi* were already flying. The larvae of both syntopic species cannot be confused (figs 65, 71).
Both species also seem to be sympatric in the Shiraz region, as the original specimens of *Z. fredi* were labelled "Fort Sine …". However, there are no recent records of *Z. fredi* from that area since its discovery there by F. Brandt in 1938.

Zygaena fredi syntopica Hofmann & Tremewan, 2003 Figs 3, 27–28, 43–44, 57

Hofmann, A. & Tremewan, W. G. 2003: 19: 17, 20, figs 1–3. Type locality: "Iran: Esfahan, Semirom vic., Kuh-e Behrouz, 2650–2900 m.".

Although other populations from the central Zagros range, e.g. from Gardaneh Meymand (Boyer Ahmad-va Kohgiluyeh, 2,550–3,000 m), from Kuh-e Bol (Fars, Eqlid SSE, 2,700–3,000 m) and from Gardaneh Timur Gun (Fars, Eqlid W, 2,650–2,750 m), are not so strongly darkened as typical *Z. fredi syntopica* from the vicinity of Semirom, they are provisionally referred to this subspecies.

Zygaena fredi valii ssp. n. Figs 4–12, 29–31, 45–47, 58

Derivatio nominis: Shah Nematollah Vali (*ca* 1350–1452 A.D.), Grand Master of Sufism, buried in Mahan/Kerman.

Material. Holotype ♂, 26 mm wingspan, "Iran, Prov. Kerman, Kuh-e Jabal Barez, ca. 5 km SSE Deh Bakri, 2600–2700 m, E 57°56,961′ / N 29°00,147′, 10.–11.v.2002 (DEHBA 6); leg. T. Keil & G. M. Tarmann", ex coll. G. Tarmann, in coll. A. Hofmann (to be deposited later in Staatliches Museum für Naturkunde Karlsruhe). – Paratypes: 1♂, 1♀, same data as holotype, coll. A. Hofmann; 8♂, 2♀, same data as holotype, coll. TLMF; 7♂, 4♀, „Südiran, Kerman, Kuh-e Gebal Barez, 60 km SW Bam, Deh-Bakri 2.500 m, 10.5.2002", leg. et coll. T. Keil; 1♂, 1♀, ibidem, 5.v.2006, leg. et coll. Ch. & Th. Keil; 1♀, „Südiran, Kerman, Qohrud-Mts., 25 km N Baft, Kefenu-Paß 2.900 m, 4.6.1998", leg. et coll. T. Keil; 1♀, „Südiran, Kerman, Qohrud-Mts. 35 km W Baft, 2.150 m, 17.5.2001", leg. et coll. T. Keil; 1♀, „Iran : Kerman, Jiroft (NW.), vic. Shingara Gardaneh Sarbishan, 2700–2900 m, 23.v.2004. Hossein Rajay [leg.]",

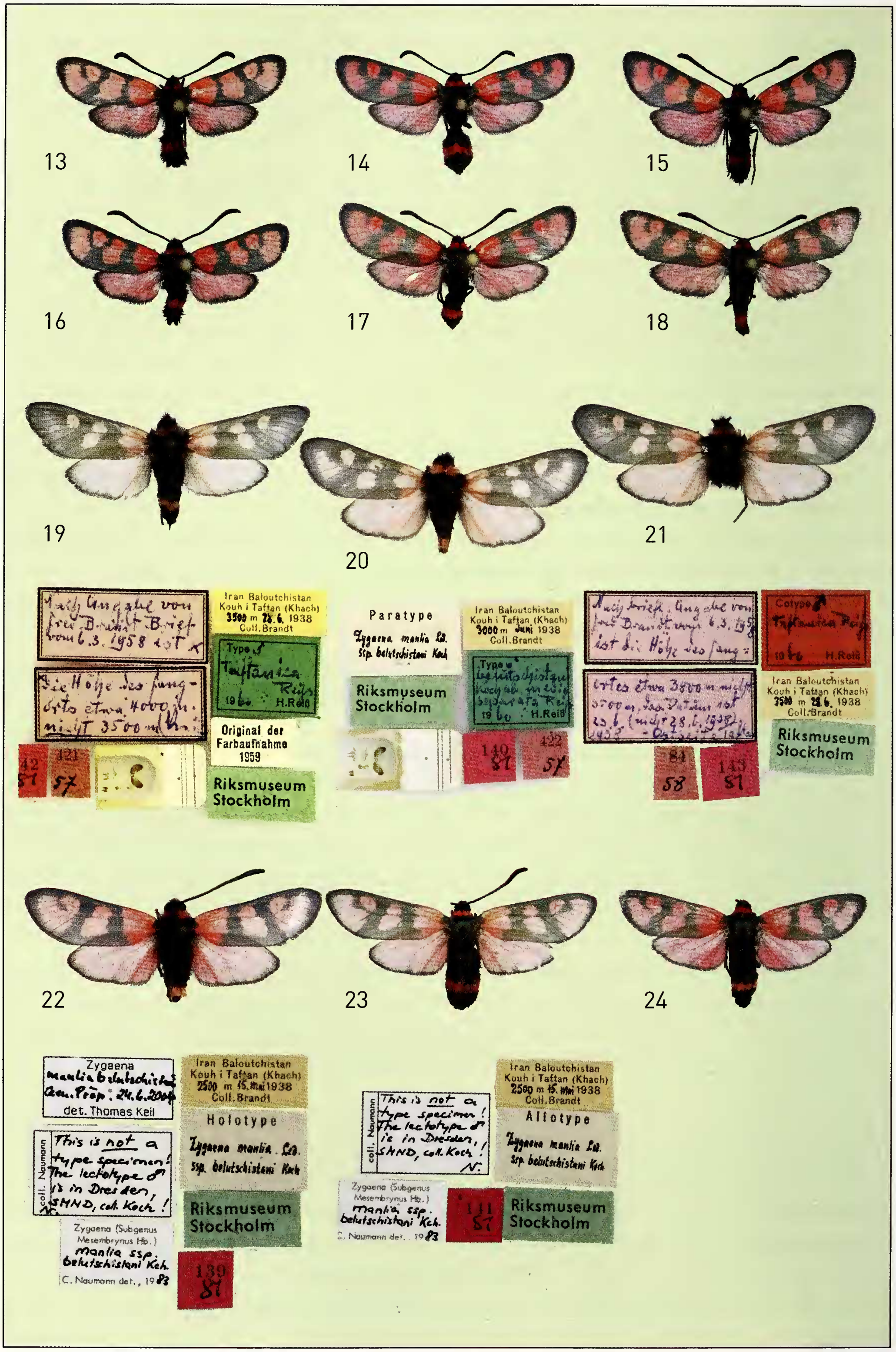
coll. W. G. Tremewan; 1♂, 1♀, same data as holotype, coll. HMIM in the Plant Pests & Diseases Research Institute, Tehran, Iran; 1♂, "C-Iran, Kerman, vic. Deh Bakri, 2500 m, 31.5.1994, leg. C. M. Naumann, Coll.-Nr. 2289", coll. A. Hofmann; 1♂, 1♀, "Südiran, Kerman, Kuh-e Gebal Barez, 60 km SW Bam, Deh Bakri, 2500 m, 10.5.2002, leg. Keil", coll. A. Hofmann; 1♀, "Iran, Kerman, Dehbakri, Gol Andaz, 2700–3000 m, 25.5.2004, A. Hofmann & T. Keil leg." coll. A. Hofmann; 3♂, 1♀, "Iran, Kerman, Jiroft NW, Gardaneh Sarbishan, Shingara vic., 2900–3100 m, [07/02], 3.6. 2002, A. Hofmann leg." coll. A. Hofmann; 1♀, "Iran, Kerman, Jiroft NW, Gardaneh Sarbishan, Shingara vic., 2600–2800 m, [08/04], 26.5.2004, A. Hofmann & J.U. Meineke leg." coll. A. Hofmann; 1♂, "Südiran, Kerman, Deh Bakri Mt., 55 km NNW Jiroft, Derba, 2800 m, 6.5.2006", leg. et coll. Ch. & Th. Keil; 4♀, "Iran, Prov. Kerman, Str. Jiroft – Rayen, 60 km nördl. Jiroft, 2400 m, 23.5.2002, M. Dietz leg.", coll. A. Hofmann; 1♀, "Iran, Kerman, Str. Jiroft – Rayen, 10 km südl. Dalford, 2400–2500 m, 2.–23.5.2002, leg. P. Hofmann", coll. A. Hofmann; 1♀, "Iran, Kerman, Darb-e Behesht, 2700–2900 m, 20.–22. 5. 2001, leg. Ramos & Westphal", coll. A. Hofmann; 2♂, 1♀, "Iran, prov. Kerman, 60 km N. Jiroft, 16/25-5-05, 2950–3250 m, Collection [leg.] G. Betti, coll. A. Hofmann"; 3♂, 2♀, "Iran: Qohrud Mts., Sarbijan, 2700–2900 m, 29°05′ N, 57°33′ E, 04.–06.06.2005, leg. Jiri Klir", coll. J. Klir/Litomerice; 1♂, 3♀, „Iran, Sarbijan, 2700–2900 m, 04.06. 2005, lgt. Bures V., N 25 05 00 E 57 32 37", coll. A. Hofmann.

Diagnosis. Of medium size (♂ 25–27 mm, ♀ 25–28 mm). Head and antenna black, thorax black with double red patagia, abdomen black with a red cingulum present on one segment, closed on the underside, always present in both sexes, extremities black. Forewing ground colour black with slight greenish sheen, coloration of spots warm red. Basal blotch formed by confluence of spots 1+2+2a; spot 2 prominent, spots 1 and 2a small, longitudinal, each forming a streak; spot 2a reaching the dorsum of wing, while a black streak along the costa is located above spot 1; spot 3 small, triangular (occasionally rounded), never connected to subquadrate, well-developed spot 4. Spot 5 in size between that of spots 4 and 3, oval or rounded-subquadrate, isolated, occasionally connected to spot 6 in the area crossed by the medial veins. Spot 6 elongate, always reduced in its upper part. Hindwing warm red, slightly translucent, especially in the discal area. Black border pronounced from apex to the anal field and significantly developed as a tooth near tornus, the tooth extending towards the translucent field (this character is less significant in specimens from further west (Shingara and Darb-e Behesht). Easily distinguished from all other populations of *Z. fredi* by the remarkable tooth on the hindwing and the always reduced spot 6 in its upper part.

Male genitalia (n = 3). Uncus processes very short, triangular (Figs 29–31), lamina dorsalis with 4 "Hauptdorne" present on each side (figs 45–47); these characters agree well with the genitalia of the male specimen of *Z. fredi* from Estabanat figured by Görgner & Hofmann (1982: 51, figs 7.1–7.4). The uncus of *Z. fredi syntopica* is of the same shape, although it appears to be slightly longer; the "Hauptdorne" on the lamina dorsalis are less pronounced.

Female genitalia (n = 2; Fig. 58). Ostium bursae weakly sclerotized as in other Irano-Afghan *Mesembrynus* species. "Schildchen" very characteristic, crescent-shaped, more weakly developed than in *Zygaena mirzayansi* sp. n. (Fig. 61).

Distribution. *Zygaena fredi valii* ssp. n. is restricted to the province of Kerman where specimens have been found by several lepidopterists in at least five localities on the south side of the Kuh-e Hezar, between Darbmarzar and Deh Bakri. No records are available from the north side of the high mountains such as Kuh-e Hezar and Kuh-e Lallezar.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Iran Baloutchistan Kouh i Taftan (Khach) 3500 m 28.6. 1938 Coll. Brandt
Type
H.Reiß
Original der Farbaufnahme 1959
Riksmuseum Stockholm
Paratype
Zygaena manlia Ld. ssp. belutschistani Koch
Riksmuseum Stockholm
Iran Baloutchistan Kouh i Taftan (Khach) 3000 m Juni 1938 Coll. Brandt
Type
H.Reiß
Cotype
H.Reiß
Iran Baloutchistan Kouh i Taftan (Khach) 3500 m 28.6. 1938 Coll. Brandt
Riksmuseum Stockholm
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23
24
Zygaena
det. Thomas Keil
coll. Naumann
This is not a type specimen! The lectotype ♂ is in Dresden, SMND, coll. Koch!
Zygaena (Subgenus Mesembrynus Hb.) manlia ssp. belutschistani Kch.
C. Naumann det., 1983
Iran Baloutchistan Kouh i Taftan (Khach) 2500 m 15. Mai 1938 Coll. Brandt
Holotype
Zygaena manlia Ld. ssp. belutschistani Koch
Riksmuseum Stockholm
coll. Naumann
This is not a type specimen! The lectotype ♂ is in Dresden, SMND, coll. Koch! N.
Zygaena (Subgenus Mesembrynus Hb.) manlia ssp. belutschistani Kch.
C. Naumann det., 1983
Iran Baloutchistan Kouh i Taftan (Khach) 2500 m 15. Mai 1938 Coll. Brandt
Allotype
Zygaena manlia Ld. ssp. belutschistani Koch
Riksmuseum Stockholm

Bionomics. In the Gol Andaz valley (Deh Bakri vic.), at an altitude of around 2,800 m, the first moths were already flying on 10 May 2002. The latest recorded date is 4 June (Sarbishan, 2,900 m), indicating a flight period from the end of the first week of May to the beginning of June. This is extraordinarily early, as all localities are situated at high altitudes between 2,600 and 3,250 m. In the nearer vicinity of Deh Bakri, at around 2,000 m, where *Z. chirazica* and *Z. ginnereissi* are found from mid May, no specimens of *Z. fredi valii* ssp. n. were ever observed.

We have received a detailed description of this locality from our colleague G. M. Tarmann/Innsbruck: "The slopes contain strongly changing rocks of volcanic origin; they consist partly of dark, black, bluish or reddish porphyrites or volcanic ash, partly of almost white granite. In the gravel of the riverbed, even Palaeozoic chalks are notable. Here the vegetation is dominated by *Artemisia* sp. and small bushes of *Prunus* spp. Higher up, *Prangos* also occurs. The slopes are dominated by *Artemisia* sp., cushions of different *Astragalus* spp., *Acantholimon* sp., *Polygonum spinosa* and *Prunus* spp.; moreover, several small *Acer* trees are present." Several larvae of *Z. fredi valii* were found on *Bupleurum exaltatum* (M. Bieb.) or a very close related *Bupleurum.*

Taxonomic remarks. As the *Bupleurum*-feeding group was only recently recognised as a distinct species-group, further taxonomic changes are to be expected when more detailed and comparable information on the biology and distribution of several nominal taxa becomes available. For the moment it would be speculative to postulate how many nominal taxa and biospecies are involved in this species complex. Morphological and phenotypic similarities with *Z. fredi* from Estabanat, with its type-specimens from the vicinity of Shiraz, and with specimens described as *Z. fredi syntopica* suggest a taxonomic placement of *valii* as an infraspecific taxon of *Z. fredi* although this cannot be properly supported by some diagnostic characters such as the extraordinary "hind-wing tooth".

Investigating species boundaries and biotopes are of special interest as the syntopic occurrence of two or more taxa provides confirmation of their heterospecificity. From the province of Esfahan (vicinity of Semirom), the nominal taxa *Z. rubricollis tenhageni* Hofmann & Tremewan, 2003 and *Z. fredi syntopica* Hofmann & Tremewan,

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Figs 13–18. *Zygaena mirzayansi* sp. n., **13.** Holotype, ♂, (CTKD), **14.** Paratype. ♂, "Iran, Esfahan, Semirom vic., Kuh-e Behrouz, 2,700 m, 31.5.2004, leg. Thomas Keil", (CTKD). **15.** Paratype, ♂, "Iran, Esfahan, Semirom vic., Kuh-e Behrouz, Paß, 2,800–2,900 m, 2.6.2004, A. Hofmann, J.U. Meineke leg.", (CAHO). **16.** Paratype, ♀, "Iran, Bakhtiyari, 25 km E. Shar-e Kord, Sefid Dasht NW, 2,500 m, 30.5.2006, leg. Thomas Keil", (CTKD), **17.** Paratype, ♀, "Iran, Esfahan, Fereydun Shahr S, Sibak SE, Kuh-e Sibak, 2,550–2,700 m, [31/02], 17. u. 18.6.2002, [A. Hofmann, A. Kallies], J.U. Meineke leg.", (CAHO). **18.** Paratype, ♀, "C-Iran, Prov. Esfahan, Suriyan [Bavanat] SW, Madane Shayan Fenjan, 2,800 m, 8.7.2005, leg. A. Karbalaye", (CAHO). **19–21.** *Z. ?manlia taftanica* Reiss, 1960. **19.** Holotype, ♂, "Iran, Baloutchistan, Kouh i Taftan (Khach), 3,500 m, 28.6.1938, coll. Brandt", (NRMS), **20.** Paratype, ♂, same data as holotype, (NRMS), **21.** Paratype, ♀, (labelled allotype), "Iran, Baloutchistan, Kouh i Taftan (Khach), 3,000 m, Juni 1938, coll. Brandt", (NRMS). **22–23.** *Z. manlia belutschistani* Koch, 1941. **22.** Paratype (non holotype!), ♂, "Iran, Baloutchistan, Kouh i Taftan (Khach), 2500 m, 15.5.1938, coll. Brandt", (NRMS), **23.** Paratype, ♀, (labelled allotype), same data, (NRMS). **24.** *Z. ?manlia* ssp. ?, "Iran, Elbursgebirge, Nissa, 2,500 m, 28.7.1936, coll Brandt", (NRMS).

2003 were described, their type-localities (biotopes) being on the same mountain slope. Ecologically, they are only slightly separated by their different phenologies. While the adults of *Z. seitzi tenhageni* occur together with *Z. haematina* from the beginning to the middle of June and can even be observed until the first week of July, *Z. fredi syntopica* flies together with *Z. chirazica*, both species occurring earlier and are at the end of their flight period when *Z. seitzi tenhageni* and *Z. haematina* begin to emerge. Surprisingly, in 2002 a further biospecies of this complex was discovered at the same locality by Thomas Keil. Investigations at home and comparisons with all other species have shown that this new species is related to the other two syntopic *Mesembrynus*-species and it is described below.

Etymology. Shah Nematollah Vali (*ca* 1350–1452 A.D.), Grand Master of Sufism, buried in Mahan/Kerman.

Zygaena mirzayansi sp. n. Figs 13–18, 37, 53, 61

Material. Holotype ♂, 27 mm wingspan, "Iran, Esfahan, Semirom vic., Kuh-e Behrouz, 2.700 m, 30.5.2002, leg. Thomas Keil", coll. T. Keil (to be deposited later in Staatliches Museum für Tierkunde Dresden). – Paratypes: 4♂, 1♀, same data as holotype, coll. T. Keil, 1♂, 1♀, same data as holotype, coll. A. Hofmann; 5♂, 4♀, ibidem, 31.5.2004, leg. et coll. T. Keil; 1♂,"Iran, Semirom vic., Kuh-e Behrouz, 2.700 m, 2.6.2007, leg. et coll. Thomas Keil; 1♀, ibidem, 2.6.2007 e.l., leg., cult. et coll. Thomas Keil; 11♂, 7♀, "Iran, Esfahan, Semirom vic., Kuh-e Behrouz, 2800–2900 m, [14/04], 1.–2.6. 2004, leg. A. Hofmann & J.-U. Meineke", coll. A. Hofmann; 1♂, 1♀, same data, coll. Hayk Mirzayans Insect Museum, Plant Pests & Diseases Research Institute, Tehran, Iran; 1♂ "Iran: Esfahan, vic. Semirom, Kuh-e Behrouz, 2650 m. 1.vi.2004. W. G. Tremewan." leg. et coll. W. G. Tremewan; 1♂, ibidem, 2.vi.2004, leg. et coll. W. G. Tremewan; 1♂, 1♀ (copula), "Iran: Esfahan, vic. Semirom, Kuh-e Behrouz (pass), 2900 m. 2.vi.2004. W. G. Tremewan." leg. et coll. W. G. Tremewan; 1♀, "Iran, Esfahan, Fereydun Shahr S, Sibak SE, Kuh-e Sibak, 2550–2700 m, 18.6.2002, A. Hofmann, A. Kallies & J.-U. Meineke", coll. A. Hofmann; 1♂, 1♀, "C-Iran, Prov. Esfahan, Suriyan (Bavanat) SW, Madane Shayan Fenjan, 2800 m, 8.7.2005, leg. A. Karbalaye", coll. A. Hofmann; 2♀, "C-Iran, Prov. Esfahan, Suriyan (Bavanat) SW, Madane Shayan Fenjan, 3100 m, 21.7.2005, leg. A. Karbalaye", coll. A. Hofmann; 1♂, "Iran, Bakhtiyari, 25 km E Shahr-e Kord, Sefid Dasht NW, 2500 m, 30.5.2006, leg. Thomas Keil", coll. T. Keil; 1♂, ibidem, 31.5.2007, leg. et coll. T. Keil.

Diagnosis. Species of medium size (♂ 25–28 mm, ♀ 25–30 mm). Head and antenna black, antennae short, especially in females. Thorax black with double red patagia, abdomen black with a red cingulum present on one segment, closed on the underside, always present in both sexes, extremities black; abdomen and thorax in males noticeably hairy, in fresh moths reminding one of *Z. exulans*. Forewing ground colour black, without sheen, coloration of spots warm red, spots 1+2+2a confluent, forming a blotch but never reaching the dorsum of wing where a black streak is always present; spot 3 small, triangular, always connected to subquadrate spot 4, without any tendency of separation. Spot 5 variable, rounded, mostly isolated, occasionally connected to spot 6 in the area of the medial vein. Spot 6 elongate. Hindwing warm red, a black border pronounced at apex and as a double tooth near tornus, which occasionally extends into the discal area when there is a tendency to divide the red field by a black streak that is also visible on the underside.

Male Genitalia (n = 5). Uncus processes short, broad basally, triangular (Fig. 37), lamina dorsalis narrower basally, distally extending with 5–6 "Hauptdorne" present on each side; distal spines protruding beyond distal end of lamina dorsalis (Fig. 53). Compared with the other two syntopic *Mesembrynus* species, the processes of the uncus are more triangular in *Z. mirzayansi* sp. n. In the lamina dorsalis of *Z. fredi* and *Z. seitzi tenhageni*, the main spines are less significant and the basal part of the lamina is broader basally.

Female Genitalia (n = 1; Fig. 61). Ostium bursae weakly sclerotized, "Schildchen" well developed, triangular.

Bionomics. In the vicinity of Semirom the new species was found at two separate, not very steep, east to south-east facing slopes about 2–3 km from each other. In both localities, *Z. mirzayansi* sp. n. inhabits weakly grazed, comparatively mesophilous biotopes that are relatively rich in herbs mixed with high grasses. Only a single male was found at the adjacent, very steep boulder scree , where *Z. chirazica*, *Z. haematina* and *Z. fredi syntopica* are common.

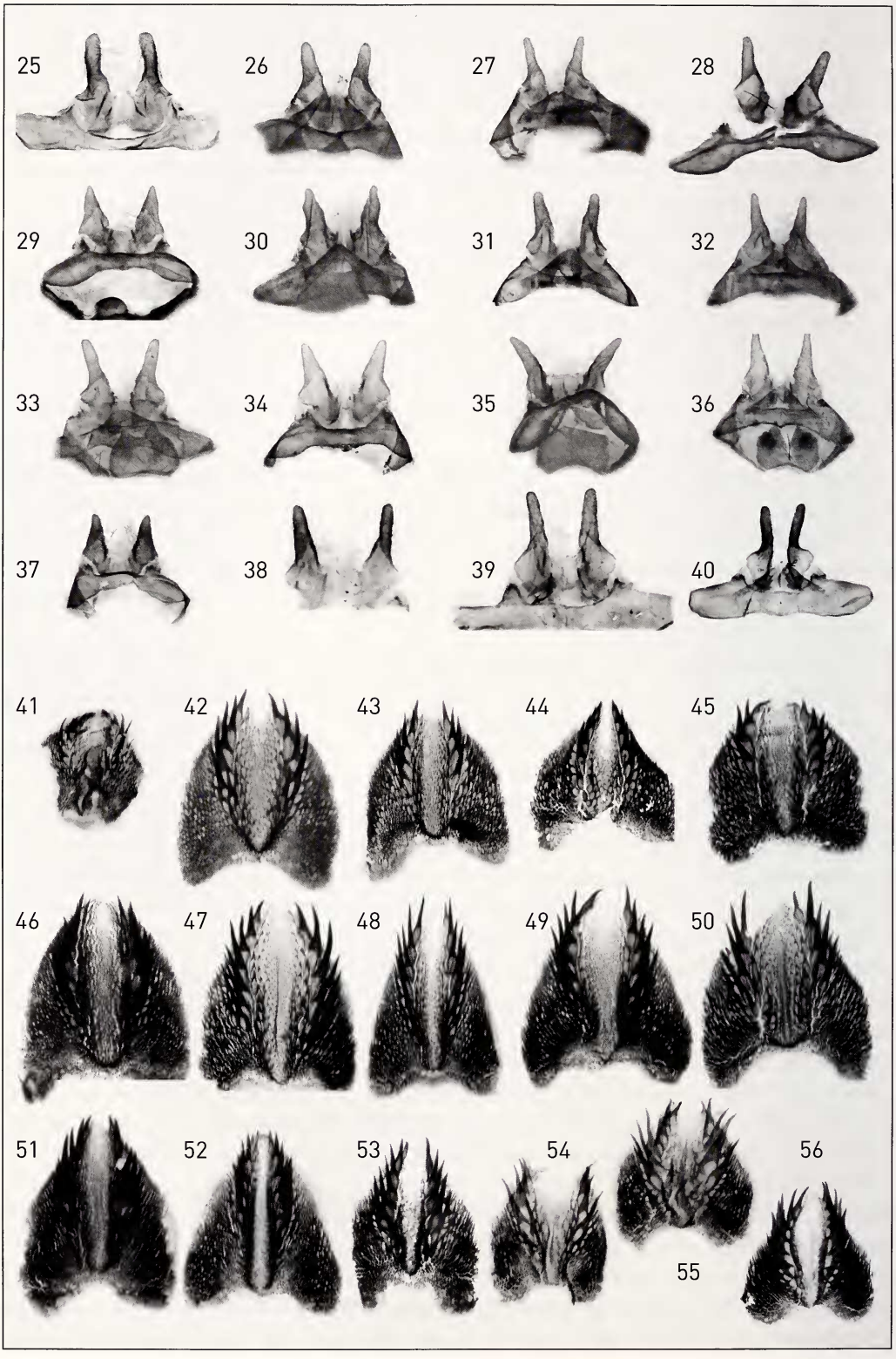
At the type-locality, moths were observed from 30 May–2 June and were flying synchronously with *Z. rosinae*, while the other syntopic species begin to fly during the second half of the flight period of *Z. mirzayansi* sp. n. It is remarkable that all three biotopes are located at an altitude of over 2600 m. Therefore, the flight period seems to be relatively early in the season. This may be one reason why this new species was not discovered before.

During several days at the beginning of June 2004, copulae were observed relatively early, between 12.00 h and 13.00 h local time, some of the copulae being accompanied by a second male. Not a single un-copulated female was observed, thus indicating that this is the normal mating time of *Z. mirzayansi* sp. n. No moths were observed nectaring.

In spite of intensive fieldwork that was undertaken from 2002 to 2009 in order to find larvae or cocoons, our knowledge of the preimaginal stages of *Z. mirzayansi* sp. n. remains poor. From several larvae, all of which were referred to *Z. seitzi tenhageni* in the field, one ♀ of *Z. mirzayansi* sp. n. emerged (e.p.: 10.7.2007, cult. T. Keil). The fully grown larva was found on the underside of an *Eryngium* leaf. It is very similar in coloration to that of *Z. seitzi tenhageni*. However, there is a good character for separating it from *Z. seitzi tenhageni*, viz. the black setae that are shorter and are present on all segments (Figs 66, 67).

Systematic position. As long as no molecular investigations have been undertaken for comparison with the phylogenetic tree published by Niehuis et al. (2007), no satisfactory decision can be made on the systematic position of *Z. mirzayansi* sp. n. except that it belongs in the subgenus *Mesembrynus* and that it might be closely related to some of the species that were formerly placed under *Z. rubricollis*.

Moreover, detailed data on the preimaginal biology and confirmation of the larval hostplant are urgently needed. The fact that *Z. mirzayansi* sp. n. is syntopic with *Z. fredi syntopica* and *Z. seitzi tenhageni* shows that conspecificity of *Z. mirzayansi* sp. n. with either of these two taxa is not possible. Without this evidence, which was obtained directly during fieldwork, one would hesitate to separate it as a distinct species in spite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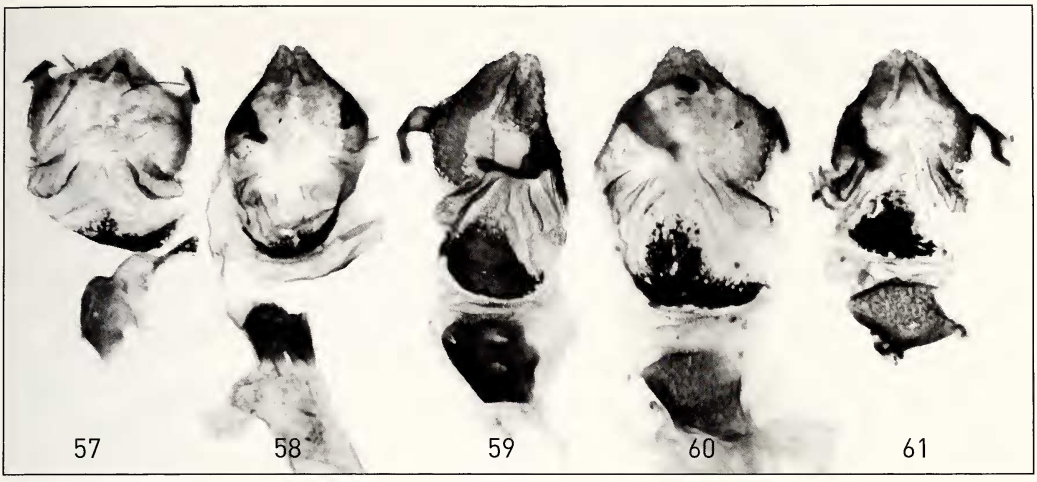

Figs 57–61. Female genitalia. **57.** *Zygaena fredi syntopica* Hofmann & Tremewan, 2003, Semirom, Kuh-e Behrouz 2,700 m, 31.v.2004, leg. Keil, GU 507, CTKD. **58.** *Z. fredi valii* n. subsp., Deh Bakri 2,500 m, 10.v.2002, leg. Keil, GU 508, CTKD. **59.** *Z. rubricollis tenhageni* Hofmann & Tremewan, 2003, Semirom, Kuh-e Behrouz 2,700 m, e.l. 8.v.2005, leg. Keil, GU 506, CTKD. **60.** *Z. manlia kermanensis* Tremewan, 1975, 25 km N Baft, Gardaneh-ye Kefenu 2,900 m, 4.vi.1998, leg. Keil, GU 510, CTKD. **61.** *Z. mirzayansi* sp. n., Semirom, Kuh-e Behrouz 2,700 m, 31.v.2004, leg. Keil, GU 509, CTKD. (photos T. Keil)

of some of the extraordinary phenotypic characters : the strongly haired thorax and abdomen, the connection of the black ground colour dorsad of spot 2a to the thorax and the strange double tooth of the hindwings underline the isolated position of this new species.

Distribution. In the same year when T. Keil found the first specimens at Semirom, J.-U. Meineke collected a single female near the village of Sibak, south of Fereydun Shahr. Here *Z. mirzayansi* sp. n. is syntopic with other *Mesembrynus* species (*Z. man-*

Figs 25–56. Male genitalia. **25–40.** Uncus-tegumen complex, **41–56.** Lamina dorsalis. **25, 41.** *Zygaena fredi* Reiss, 1938, holotype, (data see Fig. 1). **26, 42.** *Z. fredi* ad *escaleraiana* Holik, 1958, 20 km NW Damaneh, Kuh-e Dere Bid, Godar Chonsar 2,660 m, 14.vi.2000, leg. Keil, GU 442, CTKD. **27, 43.** *Z. fredi* ad *syntopica* Hofmann & Tremewan, 2003, Kuh-e Dinar, 5 km S Meimand 2,400 m, 6.vi.1999, leg. Keil, GU 445, CTKD. **28, 44.** *Z. fredi syntopica,* Semirom, Kuh-e Behrouz 2,700 m, 17.vi.2003, leg. Keil, GU 451, CTKD. **29, 45.** *Z. fredi valii* n. subsp., Deh Bakri 2,500 m, 10.v.2002, leg. Keil, GU 440, CTKD. **30, 46.** *Z. fredi valii* n. subsp., 40 km N Baft 2,600 m, 18.v.2001, leg. Keil, GU 450, CTKD. **31, 47.** *Z. fredi valii* n. subsp., 35 km W Baft 2,150 m, 17.v.2001, leg. Keil, GU 449, CTKD. **32, 48.** *Z. manlia kermanensis* Tremewan, 1975, 20 km SE Surmaq 2,150m, 24.iv.2001, leg. Klir, GU 447, CTKD. **33, 49.** *Z. manlia kermanensis* Tremewan, 1975, 20 km E Neyriz, Chasanabad 2,000m, 15.v.2001, leg. Keil, GU 448, CTKD. **34, 50.** *Z. manlia askarii* Tremewan, 1975, GU 446 (T. Keil): Qaderabad-Paß, 2,200 m, 14.v.2001, leg. Keil, CTKD. **35, 51.** *Z. ginnereissi* Hofmann, 2003, Deh Bakri 2,500 m, 10.v.2002, leg. Keil, GU 444, CTKD. **36, 52.** *Z. rubricollis tenhageni* Hofmann & Tremewan, 2003, Semirom, Kuh-e Behrouz 2,700 m, e.l. 18.v.2002, leg. Keil, GU 441, CTKD. **37, 53.** *Z. mirzayansi* sp. n., Semirom, Kuh-e Behrouz 2,700 m, 30.v.2002, leg. Keil, GU 439, CTKD. **38, 54.** *Z.* ?*manlia taftanica* Reiss, 1960 (data see Fig. 19). **39, 55.** *Z.* ?*manlia taftanica* Reiss, 1960 (data see Fig. 20). **40, 56.** *Z. manlia belutschistani* Koch, 1941 (data see Fig. 22). (photos T. Keil)


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lia, *Z. tamara*, *Z. cambysea*). In 2005, A. Karbalaye and a colleague from Esfahan collected a small series of the new species in the vicinity of Suriyan, thus confirming that the species has a wider distribution in the central Zagros range. One further record was made in 2006 when T. Keil found the new species near Shahr-e Kord, where it flies together with *Z. rosinae*, *Z. tamara* and other *Zygaena* species. It can therefore be assumed that this early-flying species will be found in further localities within this area and new records are also expected further north and south-east in the Zagros range.

Etymology. Dedicated to the Iranian entomologist Hayk Mirzayans (1920–1999) who, in 1945, founded the Insect Museum at Evin/Tehran.

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Figs 62–71. Preimaginal stages of *Zygaena fredi*, *Z. mirzayansi* and closely related species. **62–67.** Fully grown larvae. **62.** *Z. ginnereissi* (Iran, prov. Kerman, Jiroft NNW, Shingera vic., Gardanye Sarbishan, 2,600–2,800 m, e.o., iv.2005, leg. et cult. A. Hofmann). **63.** *Z. fredi syntopica* (Iran, prov. Esfahan, Semirom, vic. Kuh-e Behrouz, 2,800 m, 9.v.2005, leg. et cult. T. Keil). **64.** *Z. fredi escaleraiana* (Iran, Prov. Lorestan, Dorud 22 km E, Darb Astaneh / Saravand E: "Kuh-e 66", 3,200–3,250 m, 24.vi.2009, leg. et cult. A. Hofmann). **65.** *Z. fredi escaleraiana* (Iran, prov. Chaharmahal-va-Bakhtiyari, Zarde-Kuh-reg., Samsami vic., Gardaneh-ye Cheri, 2,800–2,950 m, 17.vi.2009, leg. et cult. A. Hofmann). **66.** *Z. mirzayansi* (Iran, prov. Esfahan, Semirom, Kuh-e Behrouz 2,700 m, 2.vi.2007, leg. T. Keil). **67.** *Z. seitzi tenhageni* (Iran, prov. Prov. Esfahan, Semirom vic., Kuh-e Behrouz, 2,800 m, e.o., iv.2005, leg. et cult. A. Hofmann). **68–70.** Batches of eggs. **68.** *Z. fredi syntopica* deposited on *Bupleurum exaltatum* (Iran, prov. Esfahan, Semirom, Kuh-e Behrouz 2,700 m, 9.v.2005, leg. T. Keil). **69.** *Z. fredi valii* (same data as in Fig. 63). **70.** *Z. fredi syntopica* (Iran, prov. Fars, Eqlid SSE, Kuh-e Bol, Darre Zard Ab, 2,750–2,900 m, 12.vi.2009, leg. et cult. A. Hofmann). **71.** Fully grown larva of *Z. seitzi* syntopic with *Z. fredi* (Fig. 65) hidden in a gap between stones (Iran, prov. Chaharmahal-va-Bakhtiyari, Zarde-Kuh-reg., Samsami vic., Gardaneh-ye Cheri, 3,000–3,100 m, 17.vi.2009, leg. et cult. A. Hofmann).

References

Alberti, B. 1958–1959. Über den stammesgeschichtlichen Aufbau der Gattung *Zygaena* F. und ihrer Vorstufen (Insecta, Lepidoptera). – Mitteilungen aus dem Zoologischen Museum in Berlin **34**: 245–396, pls 1–32 (1958); **35**: 203–242, pls 33–64 (1959).

Görgner, E. & Hofmann, A. 1982. Eine neue Zygaenenart für die Türkei (Lepidoptera; Zygaenidae, *Zygaena* Fabricius, 1775, Subgenus *Mesembrynus* Hübner, [1819]). –Entomofauna **3**: 33–54, figs 1–7.

Hofmann, A. 2000. Contribution to the knowledge of the genus *Zygaena* Fabricius, 1775 in Iran (Lepidoptera, Zygaenidae). Part I: Introduction, systematic part: *Zygaena* (*Mesembrynus*) *seitzi*, *Z.* ?*seitzi nocturna*, *Z. manlia*. – Linneana Belgica, Wetteren **17**: 171–196.

Hofmann, A. 2009. Zur Präimaginalbiologie afghanischer Rotwidderchen-Arten: *Zygaena rubricollis* Hampson, 1900 (Lepidoptera: Zygaenidae). – Entomologische Zeitschrift, Stuttgart **119** (4) 2009: 161–166.

Hofmann, A. & Kia-Hofmann, T. 2008. Contribution to the knowledge of the genus *Zygaena* Fabricius, 1775 in Iran (Lepidoptera, Zygaenidae). Part VIII: Bionomics of high-mountain species in the Alborz Mountains and adjacent areas (introduction; *Z. speciosa*, *Z. cacuminum*). – Nota lepidopterologica **31** (1): 25–52.

Hofmann, A. & Tremewan, W. G. 1996. A Systematic Catalogue of the Zygaeninae (Lepidoptera: Zygaenidae). – Harley Books, Colchester, Essex, England, 251 pp.

Hofmann, A. & Tremewan, W. G. 2001. Contribution to the knowledge of the genus *Zygaena* Fabricius, 1775, in Iran (Lepidoptera, Zygaenidae). Part V: *Zygaena tamara*. – Linneana Belgica, Wetteren **18**: 125–136.

Hofmann, A. & Tremewan, W. G. 2003. Contribution to the knowledge of the genus *Zygaena* Fabricius, 1775, in Iran (Lepidoptera, Zygaenidae). Part VI: *Zygaena nocturna*, *Z. aisha*, *Z. rubricollis* and *Z. fredi* (addenda based on results of fieldwork in 2001 and 2002). – Linneana Belgica, Wetteren **19**: 9–20.

Holik, O. 1958. *Zygaena* (*Coelestis*) *seitzi escaleraiana* n. ssp. – Entomologische Zeitschrift **68**: 17.

Keil, Th. 2003. New data on the biology of *Zygaena* (*Agrumenia*) *rosinae* Korb, 1903 and *Z.* (*A.*) *sengana* Holik & Sheljuzhko, 1956 stat. rev. in south Iran (Lepidoptera: Zygaenidae, Zygaeninae). – Abstracts of the VIII International Symposium on Zygaenidae, Dresden – Germany, 10–14 September 2003: 29–30.

Keil, Th. 2003. Attend for a new classification of the taxa around *Zygaena rubricollis* Hampson, 1900 (Lepidoptera: Zygaenidae, Zygaeninae). – Abstracts of the VIII International Symposium on Zygaenidae, Dresden – Germany, 10–4 September 2003: 31–32.

Reiss, H. 1938. Die Zygaenen der Umgebung von Chiraz (Provinz Fars) in Südiran. – Entomologische Rundschau, Stuttgart **55**: 249–254, 290–292, 310–314.

Tremewan, W. G. 1979. On *Zygaena* Fabricius (Lepidoptera: Zygaenidae) from Iran. – Entomologist's Gazette, Brightwood **30**: 249–256.

Tremewan, W. G. 2002. The Genetics of Burnet Moths, *Zygaena* Fabricius, 1775 (Insecta: Lepidoptera, Zygaenidae, Zygaeninae). Unpublished Ph.D. thesis, University of Aberdeen. xiii + 381 pp.